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Instructions for Using SOW Pk Program

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INSTRUCTIONS FOR USING SOW PK PROGRAM

22 Apr 88

PKSOW is a Fortran program developed at Lawrence Livermore National Laboratory to calculate the probability of kill (P_k) of a submarine-launched ASW nuclear standoff weapon. The calculation can be done for a broad spectrum of conditions: the user specifies weapon characteristics (yield, depth of burst), target localization and course and speed errors, target evasion tactics, target damage specifications, and safe standoff parameters. Output from the program includes a table of Pk at various standoff ranges for each of several yields.

This version of PKSOW has been adapted to run on the IBM PC using MS/DOS. The output from the program may be used with MS CHART to produce plots of Pk vs. standoff range.

If you have any problems with the code, or if these instructions aren't clear, I would like to hear from you. Please call Doug Magnoli, 415-422-6561.

The program is fairly simple to use. The program requires an input file, whose name, of the form filename.extension, must have DAT as the extension. When run, the program asks for the datafile name; the user reponds with the filename character string of up to 8 characters. (Note: The user supplies the filename ONLY, not the extension.) The program produces three output files:

filename.OUT is the printed output. It contains all the input parameters, gives safe standoff distances and lethal radii for all weapon yields considered, and lists Pks for each yield and range.

filename.GIN is the file containing the information (the Graphics INput) needed for MS CHART to produce graphics output.

DIAG.OUT contains diagnostic messages describing where the code may have had problems. This file will usually be empty.

Sample input and output files are included on the diskette.

This documentation describes the format of the input file for PKSOW. (Note: as a rule, it is easier to modify an existing input file than to generate a new one from scratch.)

The user is cautioned that the code can be slow to run. The test data file included on the diskette asks for calculations of Pk at 5 ranges for each of 3 yields, with 1000 Monte Carlo trials for each of those. This dataset takes about 7 minutes to run on the IBM PC.

As computation is finished for each range and yield, a message is printed to the screen, indicating how far along the calculation has come and allowing the user to figure approximately how long the entire run will take.

Running PKSOW

The enclosed diskette contains the source code for PKSOW as well as the executable file (pksow.for and pksow.exe). The executable requires that the IBM PC be equipped with the 8087 arithmetic chip. If you want to use the program on a machine without the 8087, it will have to be recompiled using the appropriate math library.

A sample input file, called test.dat, is also included on the disk. Descriptions of input parameters follow.

INPUT FILE: filename.DAT

The following table describes the input to PKSOW. Unless marked with an asterisk, all data must be included for each calculation. Lines marked with an asterisk indicate data whose inclusion depends on the value of the preceeding parameter. For example, line 1, number of weapons to be fired, must be included. If NWEPS > 1, lines 1a - 1c are also required; if NWEPS = 1, lines 1a - 1c must be omitted. It is important to remember that changing data may require adding or deleting a few lines in a data file.

Because the program can take a long time to run, it is useful to ensure that all the data is being read as desired before completing the calculation. To do this, set IDATTEST (line 41) to 1 and run PKSOW. The program will read in all the data and stop before doing the calculation. The output file can be read and the data file can be corrected if necessary. To run the program, change IDATTEST to 0 and run.

A sample input data file appears at the end of the table.

Line No.	Variables	Format	Description and Comments	
1	NWEPS	i1	Number of weapons to be fired in this engagement (no more than 3)	
* 1a	SALTIME	f6.1	Time between shots (sec) (Use 0.0 for MRV)	Enter only if NWEPS > 1
* 1b	IPAT	i1	Drop pattern 1 for linear 2 for triangular (possible only if Nweps = 3)	Enter only if NWEPS > 1
* 1c	SEP	f8.2	Separation of weapon delivery points in units of lethal radius	Enter only if NWEPS > 1
2	ILEAD	i2	Targeting code 1 for predicted intercept of target 2 for last known position	
3	RMIN RMAX NRANGES	f10.0 f10.0 i2	Minimum standoff range (yd) for output Maximum standoff range (yd) for output Number of range points	
4	NYIELD	i1	Number of kinds of weapons (yields) available	
5	YIELD(i)	9f8.2	Weapon yields (ktons)	
6	DOB(i)	9f8.2	Burst depth (ft) for each yield	
7	DERRFRAC DERRADD	2f8.3	Standard deviation of downrange target localization error is computed as: DERRFRAC * Range + DERRADD (yd)	
8	CERRFRAC CERRADD	2f8.3	Standard deviation of cross range target localization error: CERRFRAC * Range + CERRADD (yd)	
9	VELERR HEADERR	f8.3 f8.3	Target speed error (kt) Target heading error (degrees)	
10	CEP CEPLIN	f8.3 f8.3	CEP for weapon delivery (yd) CEP for weapon delivery (as a fraction of range)	At any given range, the larger of these will be used
11	SVEL	f10.4	Target submarine velocity (kt)	
12	IANG	i1	Code for initial sub angle with respect to downrange	

			0 = random 1 = angzero (next line)	
* 12a	ANGZERO	f10.4	Initial sub angle wrt downrange (degrees)	Enter only if IANG = 1
13	IALERT	i1	Alert code--target sub is alerted by: 0 = no alert 1 = ping 2 = launch 3 = surface break 4 = splash	
14	TCODE SCODE DCODE	i1 i1 i1	Evasion code for turn speed depth	Turn: 0 = no turn 1 = turn 90 degrees to alerting sound 2 = turn by ANGTURN (below) 3 = turn away from splash Speed: 0 = no speed change 1 = accelerate to max speed 2 = slow to min speed Depth: 0 = no depth change 1 = come to surface 2 = go to max working depth
15	TRATE	f10.4	Turn rate ($\frac{\text{deg/sec}}{\text{kt}}$)	
16	ANGTURN	f10.4	Angle of evasion turn (deg) if TCODE=2	
17	SRATE	f10.4	Deceleration (kt/sec)	
18	VMIN VMAX	f10.4 f10.4	Minimum sub velocity (kt) Maximum sub velocity (kt)	
19	ANGCD	f10.4	Dive/climb angle (deg)	
20	PRATE	f10.4	Pitch rate ($\frac{\text{deg/sec}}{\text{kt}}$)	
21	DMAX	f10.4	Maximum working depth (m)	
22	T1	f10.4	Propulsion system reaction time (sec)	
23	T2	f10.4	Time to accelerate to full speed from rest (sec)	

24	PN	f10.4	Exponent in power law fit of speed curve
25	PV	f10.4	Remaining speed fraction after 90 deg turn
26	RETIME	f10.4	Sub reaction time to commence evasion (sec)
27	TUPFAC TUPCON	2f12.6	Time for weapon to rise to surface = TUPFAC(sec/ft) * DOL(line 36) + TUPCON (sec)
28	TDNFAC TDNCON	2f12.6	Time for weapon to sink to burst depth = TDNFAC(sec/ft) * DOB(i) (line 6) + TDNFAC (sec)
29	TFLY1FAC TFLY1CON	2f12.6	If Range < RNEWKYD (line 32), time for weapon to fly to target = TFLY1FAC(sec/kyd) * Range (kyd) + TFLY1CON (sec)
30	TFLY2FAC TFLY2CON	2f12.6	If Range > RNEWKYD (line 32), time for weapon to fly to target = TFLY2FAC(sec/kyd) * Range (kyd) + TFLY2CON (sec)
31	RNEWKYD	f12.6	Range (kyd) at which time to target calculation parameters change from TFLY1FAC,TFLY1CON to TFLY2FAC,TFLY2CON
32	DOT	f10.0	Depth of target (m)
33	ILETH	i1	Lethality class 1 to calculate lethality by excess impulse 2 to calculate lethality by peak translational velocity (PTV)
* 33a	PSILMT	f10.0	Crush pressure (psi) Enter only if ILETH = 1
* 33b	PSISEC	f10.0	Psi-sec limit Enter only if ILETH = 1
* 33c	PTV	f10.0	Lethal PTV (ft/sec) Enter only if ILETH = 2
* 33d	SUBRAD	f10.0	Radius of target sub (m) Enter only if ILETH = 2
* 33e	ETA	f10.3	Orientation damage factor Enter only if ILETH = 2 ETA = 1. means that sub vulnerability is independent of sub orientation to the weapon. ETA < 1. means full vulnerability for sub oriented broadside to the explosion, but reduces lethality (to ETA) when sub is end-on.
34	RELY	f10.3	Reliability of weapon

35	TPROCES	f10.0	Time to process active ping (sec)
36	DOL	f10.5	Launch depth (ft)
37	PTVSSO	f10.5	Maximum safe shock level (PTV in ft/sec) for attacking submarine
38	OWNSRAD	f10.5	Own sub radius (m)
39	NTER	i5	Number of Monte Carlo iterations per range and yield If graphs need to be smoother, try increasing NTER. (1000 gives fairly good results.)
40	IYOPT	i1	Output code: 1 = give Pk at each range for each yield 2 = give Pk at each range for max safe yield only
41	IDATTEST	i1	0 for run 1 for checking input data
42	IDUMPQ	i1	Debugging tool: use 0 If problems arise, set NTER to something small (like 5 or 10) and use IDUMPQ = 1 to get a lot of output in file DIAG.OUT
43	IRS	i1	Restart code: 0 = finished 1 = data for another run follows any number of datasets can be stacked.

SAMPLE INPUT FILE: TEST2.DAT

NOTE: The data in this sample file (and any others on the diskette) do not include any classified values.

```
1                       number of weapons
1                       0=last known position, 1=predicted intercept
1.,60001.,31            min and max ranges (yd) and number of range points
3                       number of kinds of weaopns (yields) available
10.,100.,1000.          yields (kton)
500.,1500.,3000.         depth of burst for each yield (ft)
.1,10.               localization errors: downrange (frac of range),+ constant(kyd)
10.,0.                   localization errors: crossrange (deg), + const (kyd)
1.,1.                   velocity errors: speed error (kt) ,heading error (deg)
10.,.1                  cep absolute (yd) or fraction of range (larger is used)
10.                     sub speed (kt)
0                       sub angle code. 0 = random, 1 = value below.
3                       alert code,  1=ping alert,2=launch,3=broach,4=splash
112                     evasion codes--turn,speed,depth
1.0                     turn rate (deg/sec/kt)
90.                     evasion turn (deg) if tcode = 2
1.0                     accel(kt/sec)
1.,20.                  min,max sub speed (kt)
45.                     climb angle (deg)
.1                      pitch rate (deg/sec/kt)
1000.                   max working depth  (m)
100.                    propulsion system reaction time (sec)
1000.                   time to acc to max spd from rest (sec)
5.                      exponent for power fit of speed
.5                      remaining speed fraction after turn
1.                      target reaction time to commence evasion (sec)
.05,5.                  tupfac(sec/ft),tupcon(sec)
.02,2.                  tdnfac(sec/ft),tdncon(sec)
1.  ,10.                tfly1fac(sec/kyd),tfly1con(sec)
2. ,-20.                tfly2fac(sec/kyd),tfly2con(sec)
30.                     rnewkyd (kyd)
300.                    target depth (m)
2                       lethality class:  1 for excess impulse, 2 for ptv
5.                      lethal ptv
3.                      sub radius(m)
1.                      eta--orientation
1.0                     weapon reliability
10.                     time to process ping (sec)
100.                    launch depth (ft)
1.                      safe ptv for firing sub (ft/sec)
5.                      own sub radius (m)
00100                   number of shots at each range (salvos)
1                       1=show Pk for all yields; 2=only for max safe yield
0                       test data?  1=yes, 0=run
0                       dump of every drop?  1=yes, 0=no
0                       restart code:  0=end of run; 1=another set of data follows
```

SAMPLE OUTPUT FILES

The following is the output file TEST2.OUT generated by the input file given above. The file TEST2.GIN consists of the final table of this file and can be used with MS CHART for plotting the Pks.

ASW STANDOFF WEAPON PK CALCULATION

courtesy of Lawrence Livermore National Lab

Weapon specifications

1 weapon
Targeting based on predicted intercept.

Min range: 1. yd
Max range: 60001. yd
Number of points: 31

Calculation is for 3 yields:

Yield (kton)	Depth of burst (ft)
10.	500.
100.	1500.
1000.	3000.

Localization and firing errors

Downrange position error: .100* R + 10.00 kyd
Crossrange position error: 10.00deg + .00 kyd

Velocity error (kt): 1.000
Heading error (degrees): 1.0
Cep: the larger of 10. yd or .100 * R

Evasion specs for target submarine

Submarine velocity: 10.0 kt
Submarine orientation:
random

Alert code: 3 0 = no alert

1 = ping alert
2 = launch alert
3 = surface break
4 = splash alert

Evasion codes

Turn: 1
0 = no turn — turn rate:1.0000 deg/sec/kt
1 = turn 90 deg from firing sub
2 = 90 deg turn
3 = turn away from splash

Speed change: 1
0 = no speed change — accel: 1.0000 kt/sec
1 = accelerate to max speed — vmin: 1.0 kt
2 = decelerate to min speed — vmax: 20.0 kt

Depth change: 2
0 = no depth change — Max working depth: 1000.0 m
1 = surface — Dive/climb angle: 45.0
2 = go deep — Pitch rate (deg/sec/kt): .1000

angturn (deg): 90.0000

Propulsion system reaction time: 100.0 sec
Time to acc to max spd from rest: 1000. sec
Exponent for power fit of speed: 5.000
Remaining speed fraction after turn: .50

Reaction time to evade: 1. sec

Standoff weapon parameters

Missile rise time: .0500 * launch depth (ft) + 5.00 sec
Missile sink time: .0200 * burst depth (ft) + 2.00 sec
Missile fly time: 1.0000 * range (kyd) + 10.00 sec — Range < 30. kyd
2.0000 * range (kyd) + -20.00 sec — > 30. kyd

Target damage specifications

Depth of target: 300. m
peak translational velocity: 5.0 ft/sec
Radius of submarine: 3.0 m
Orientation damage factor: 1.0000
Reliability: 1.0000

Safe standoff considerations

Time to process ping: 10. sec

Depth of launch: 100. ft
Allowable shock level: 1. ft/sec ptv
Own sub radius: 5.0 m

No.	Yield (kt)	Dob (ft)	Dot (m)	Safe radius (kyd)	Lethal radius (kyd
1	10.0	500.	300.	4.115	2.710
2	100.0	1500.	300.	9.948	6.174
3	1000.0	3000.	300.	19.753	13.683

Pk is calculated for all ranges for all yields, 100 iterations per point.

Range (kyd)	10.0 kton	100.0 kton	1000.0 kton
.0	.210	.440	.850
2.0	.250	.450	.780
4.0	.220	.440	.790
6.0	.090	.460	.720
8.0	.160	.370	.730
10.0	.130	.440	.780
12.0	.160	.420	.810
14.0	.150	.340	.870
16.0	.140	.320	.760
18.0	.120	.290	.790
20.0	.090	.330	.660
22.0	.060	.300	.710
24.0	.090	.220	.690
26.0	.080	.220	.650
28.0	.030	.220	.660
30.0	.030	.270	.680
32.0	.030	.170	.590
34.0	.020	.140	.630
36.0	.070	.210	.630
38.0	.050	.190	.440
40.0	.030	.200	.560
42.0	.010	.100	.510
44.0	.020	.130	.530
46.0	.030	.100	.500
48.0	.020	.100	.510
50.0	.030	.100	.370
52.0	.040	.150	.500
54.0	.030	.090	.450
56.0	.000	.140	.430
58.0	.050	.090	.400
60.0	.030	.110	.430

End of run